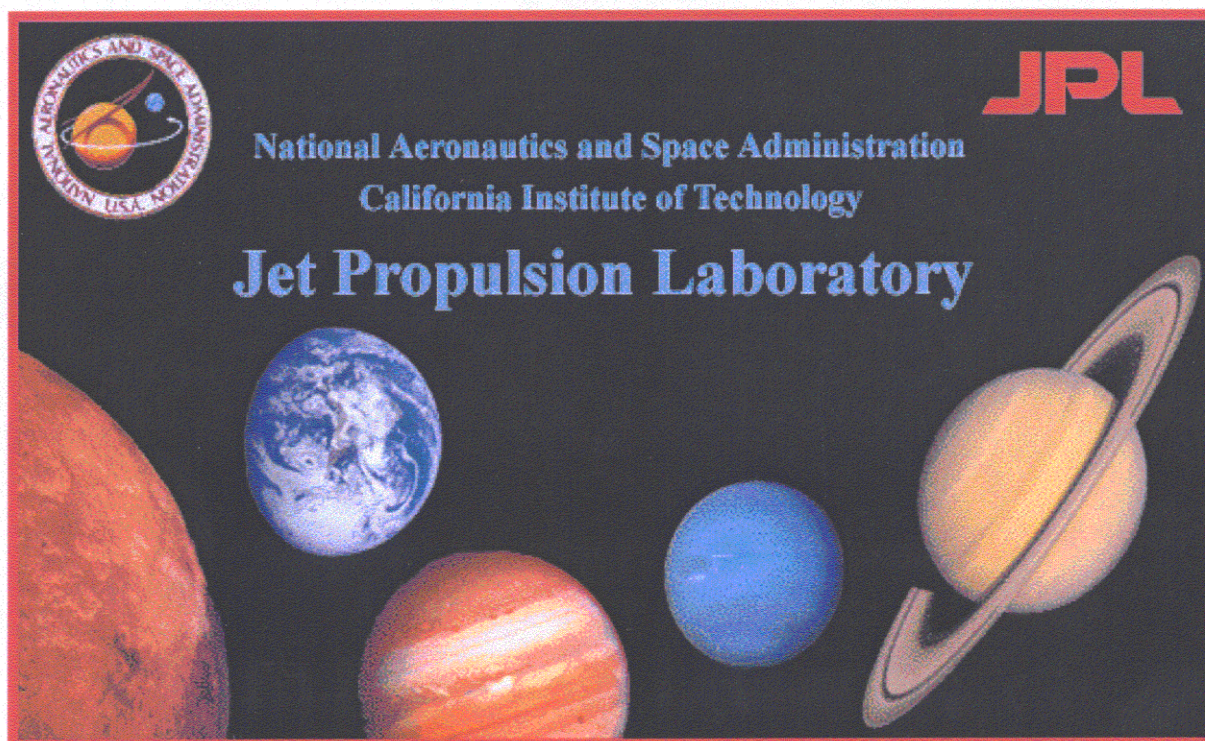




Search for Low Power Radiation Tolerant Microcircuits



Shri Agarwal and Mike Sandor
(email: shri.g.agarwal@jpl.nasa.gov)



AGENDA

Introduction

Faster, Better, Cheaper Goals

JPL Initiative

Test Results

Summary

The work was performed at Jet Propulsion Laboratory California Institute of Technology
under contract to the National Aeronautics and Space Administration



INTRODUCTION

Changing Times

The faster, better, cheaper environment at NASA expects innovative ways of satisfying mission goals. One of our goals is to provide low power Space quality parts to our Projects.

The immediate challenges for parts engineering are:

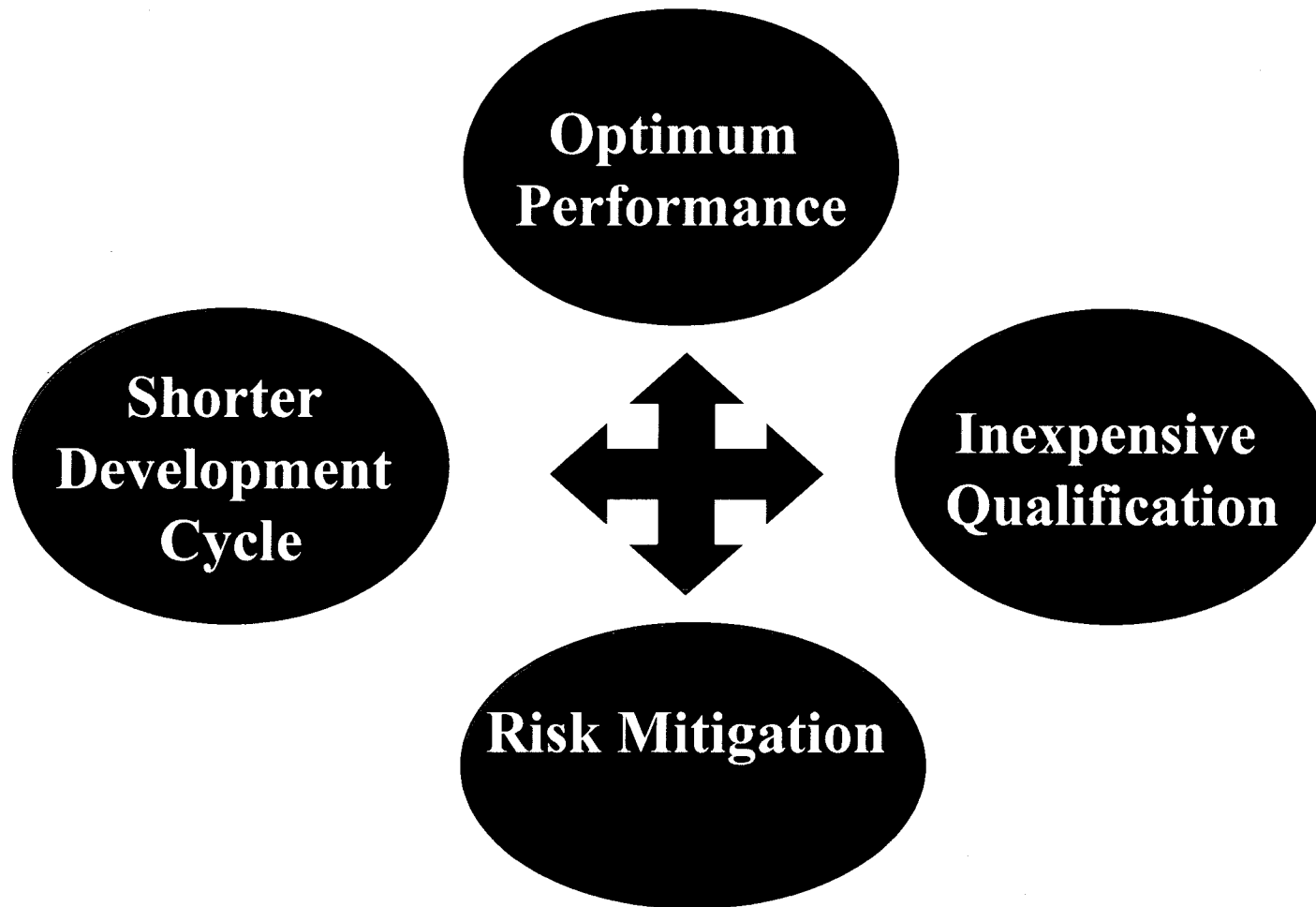
- 1. Very few new low power products are available as space quality.**
- 2. Many products are inherently low power by design but require further evaluation.**
- 3. Any candidate products we identify have to satisfy the vendors future business plans and their technical evaluation.**



INITIATIVE

- Research what new commercial/rad tolerant products are available that may be used in space applications upon further evaluation**
- Apply different evaluation strategies**
- Apply risk mitigation based on performance, cost and availability**
- Develop a roadmap with the supplier to offer low power commercial/rad hard products as Space level**

Faster, Better, Cheaper Challenges (Low Power Quest)





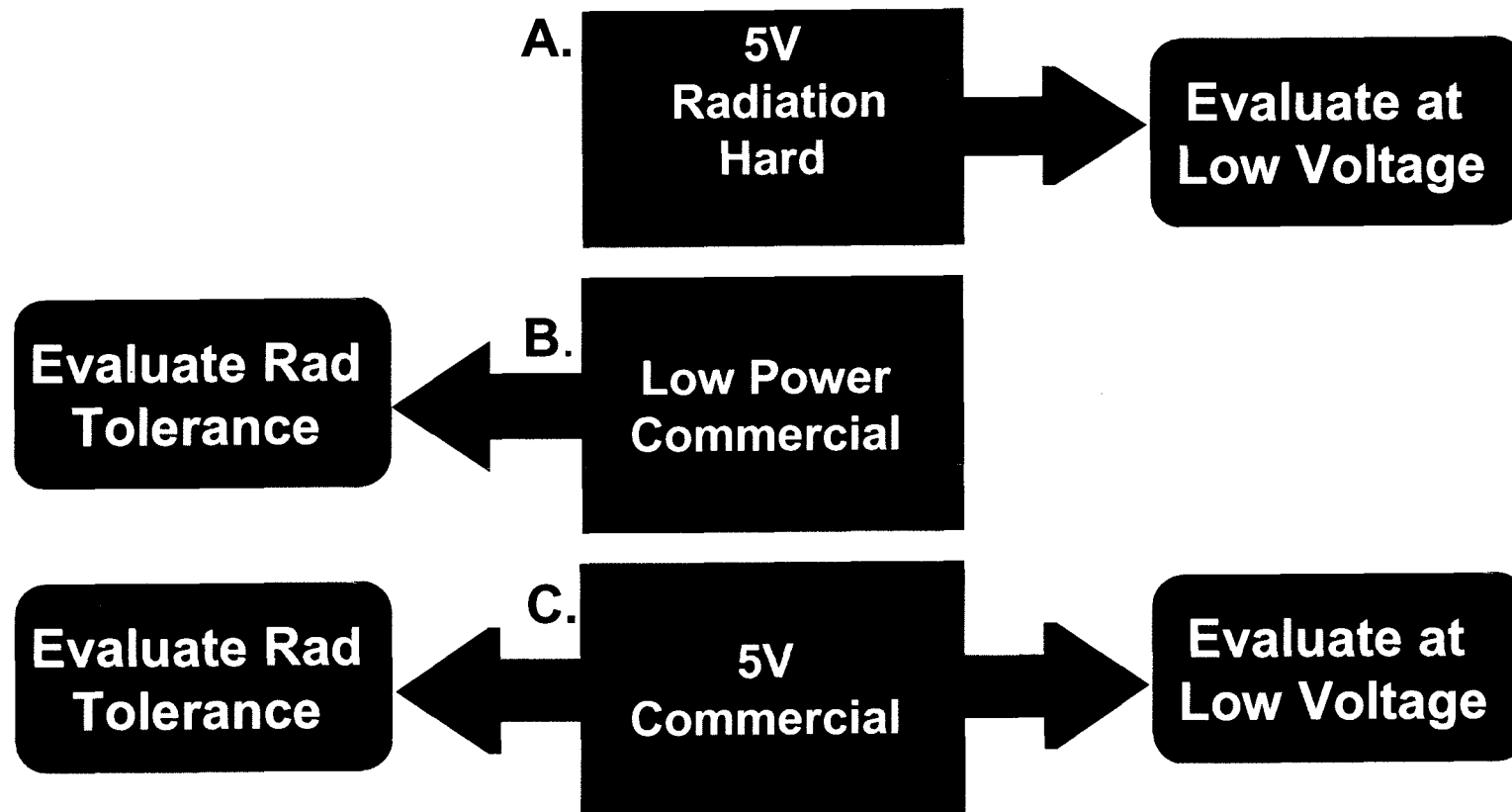
BRIEF HISTORY

30+ year history of CMOS Logic:

<u>Year</u>	<u>S/C</u>	<u>Usage</u>	<u>Capability</u>
1970s	Voyager	12V	20V
1980s	Galileo	10V	20V
1990s	Cassini	5V	7V
2000s	X2000/EO	3.3V	Varies

Each generation of spacecraft require a reduction in power budget. The CMOS technology has traditionally been preferred where low power budgets are critical. Going forward into the new century low power technologies such as CMOS and SOI will be vital for Space applications.

Evaluation Strategies to Low Power Parts:





LOW VOLTAGE TEST RESULTS

Case A

5V RH / RT

Functional down to 3V

Lower supply current

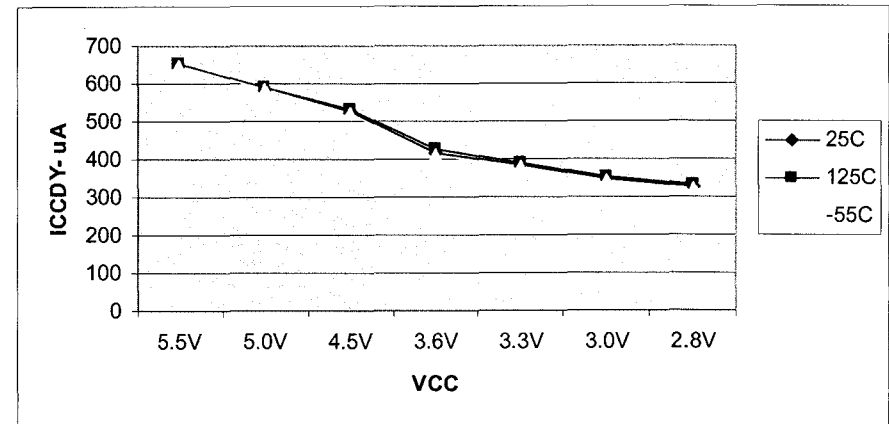
Expect some speed degradation

UTMC UT54ACS Logic
NSC 54AC Logic
Intersil ACS Logic
Intersil 26C31/32
UTMC BCRTM
UTMC 256k PROMs

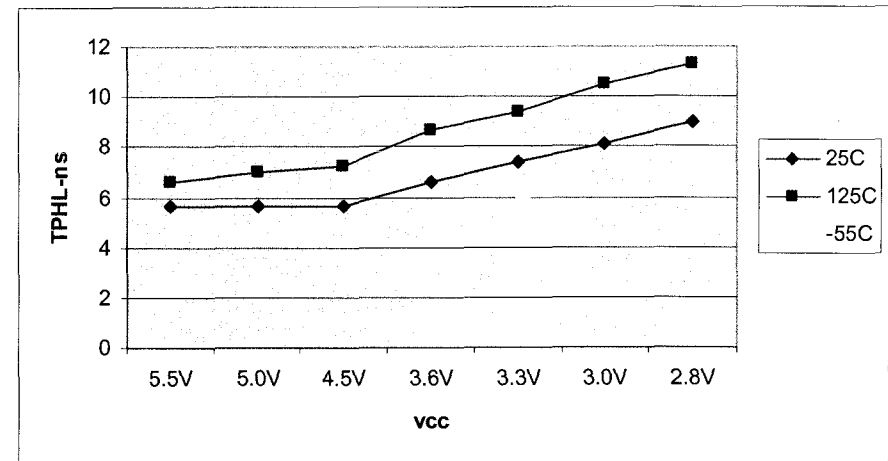
As a result of this effort, four of these devices were developed
and offered by the suppliers as 3.3V low power products.

CASE A EXAMPLE – Speed and Power

Dynamic current temperature test results at 5V and 3.3V. The current at 3.3V is expected to be about 67% of that at 5V. The actual data shows it to be pretty close to that ($400\mu\text{A}/600\mu\text{A} = .67$).

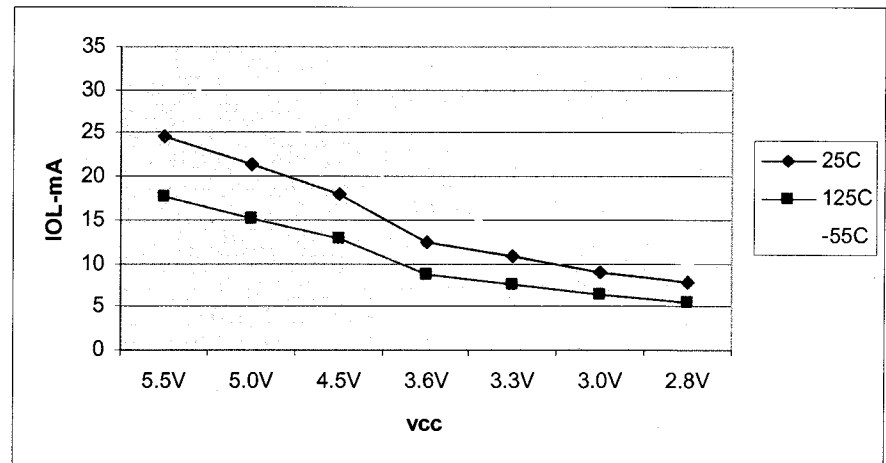
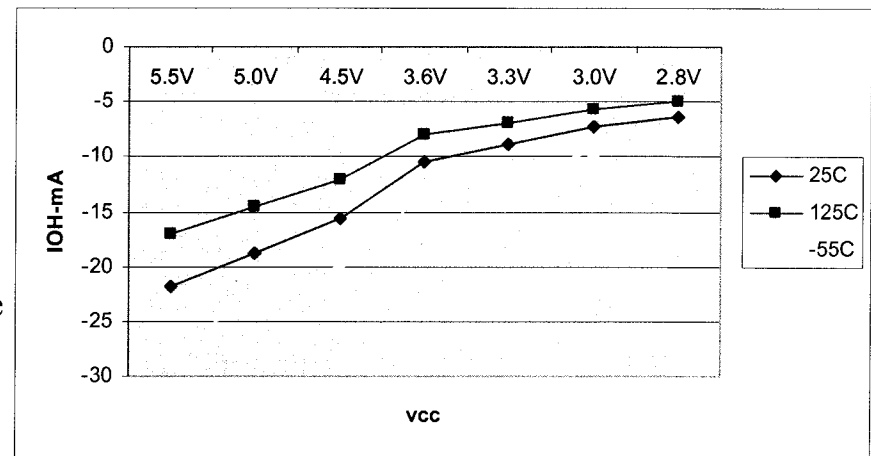


Propagation delay temperature test results at 5V and 3.3V. The part is expected to slow down by about 50% at 3.3V when compared with speed at 5V. The measured degradation in speed at 125C was about 36%.



CASE A EXAMPLE – Drive Capability

These two plots show change in output drive currents over the military temperature range. The top plot shows the source current, I_{OH} , and the bottom plot the sink current, I_{OL} . The output stage is fairly symmetrical. The measured output drives over the military temperature range varied from 5mA to 10mA at 3.3V and from 15mA to 25mA at 5V which are acceptable numbers.





RADIATION TEST RESULTS

Case B

LP Commercial

Single Event Effects: Acceptable

Total Dose: Acceptable/use shielding

Temperature: Passed Industrial/Military

LinTech LTC1419A
NSC LMC6484
NSC PLLs

As a result of this and other parallel efforts, the NSC PLL was introduced as space product. The LMC6484 is being developed at SEI/Maxwell as a standard space product. The LTC1419A is being developed for a JPL contractor as a space level product.

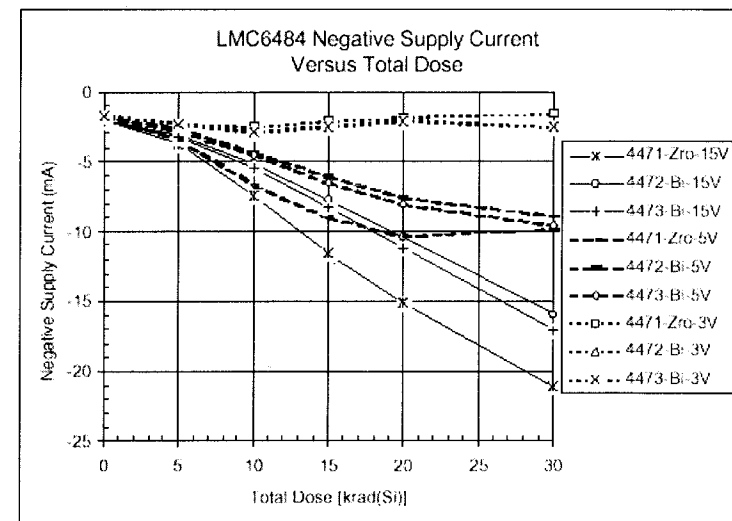
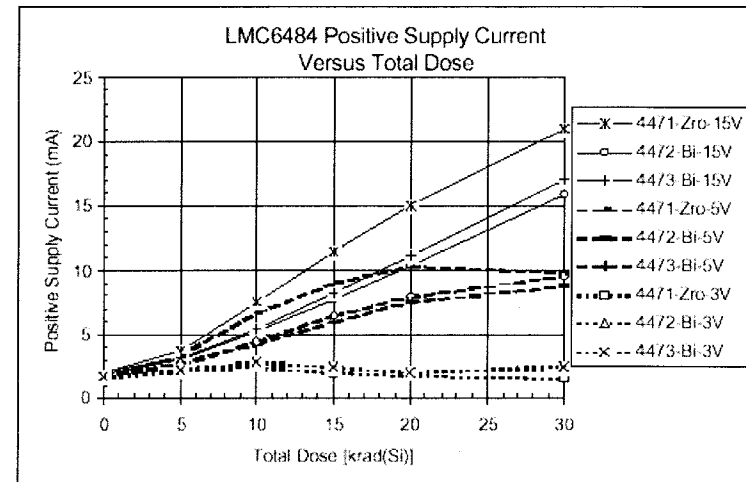
CASE B EXAMPLE – Total Dose

LMC6484 is a low power rail-to-rail OP AMP. It is built in CMOS process. JPL ran SEL and TID tests with the following results:

SEL: LET threshold >120 MeV-sq cm/mg.
No evidence of latch-up was found.

TID: Tests were done at high dose rate up to a maximum accumulated dose of 30krads. The accompanying plots show the performance of supply currents with total dose for different bias conditions. Based on the radiation test it was determined that the part would have to be shielded for radiation. The complete test report may be viewed on JPL rad data base which can be accessed via the parts engrg website: www.parts.jpl.nasa.gov.

SEI/Maxwell is developing a 6484RP for use in Space application.



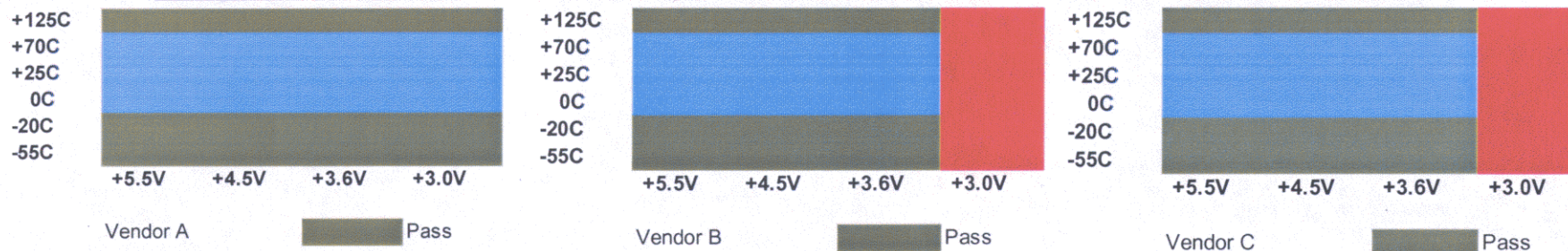
ELECTRICAL TEST RESULTS

Case C

5V Commercial

SRAMs

COTS SRAMS have been evaluated by JPL at low voltage



These parts all showed power savings by operating down to 3.6v and/ or 3.0v.



SUMMARY

- ❑ The initiatives and strategies undertaken by JPL Parts Engineering have been instrumental in JPL/NASA Projects meeting their low power goals.
- ❑ The space parts user community at large has also benefited because some vendors have introduced a family of standard low power/rad tolerant space products.
- ❑ The return on investment for this type of effort is dependent on the cooperation and planning between the users, the manufacturers, and any outside contractors used for testing.